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A COMPARATIVE STUDY OF HAIR FOR THE MEDICO-LEGAL EXPERT.

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In the examination of hair and fibers presented to the medico-legal expert, three questions naturally arise in mind, demanding intelligent answer: Is the object hair from a human body? Is it like hair from a human body? And, if so, ought that fact to influence his mind to believe it to be human hair?

Each hair presents two principal divisions, the portion embedded within the integument or root, which terminates at its lower extremity in a bulbous expansion for retention in the hair follicle, and the part which projects beyond the surface of the integument, called the shaft. To the medico-legal examiner, the root is of but little importance, signifying by its continuity with the shaft that the hair had fallen because of constitutional disease, alopecia, or had been violently removed. The shaft, however, presents naked eye and microscopic characteristics that aid materially in its determination. The former are shape, length and color, the latter with the histological divisions of the shaft are form, diameter, color, the histological divisions being the cuticle or epithelial covering; the cortical substance, consisting of elongated elements so intimately united as to be indistinguishable under ordinary circumstances, and the medulla or pith, occupying the central tract of the shaft.

On all fur-bearing animals there are two varieties of hair, known to the furriers as over hair and under hair. The over hairs are coarser, fewer and harsher, extending beyond or of equal length with the under hairs, giving the peculiar beauty and richness that marks the pelt of the Russian sable, *Mustela zibellina*. The under hairs are softer, finer and more abundant, qualities that render the seal skin, *Callorhinus ursinus*, of such value and elegance. Aside from the black-skinned races, whose hair is peculiarly kinked and curly, the hair of man's head and face is straight, while that from the axillæ, chest, arms, legs and genitalia is irregularly bent and sinuous.

The length of the hair of animals rarely exceeds six to eight inches, except that of the South American monkey, *Colobus vellerosus*, of the Angora, Astrakhan, *Ovis aries*, and other wools, and of the equine and asinine species of animals, it is not above three or four inches in length; while from many creatures, *e. g.*, the common horse, rat, *Mus rattus;* mouse, *Mus musculus*, and the red squirrel, *Sciurus hudsonius*, it is less than an inch. The hair of the mane and tail of the horse, *Equus caballus*, is commonly from eighteen to twenty-four inches long, the estimated length of the hair from woman's head. Exceptionally, the latter and the beard of man that has never been shorn reaches the great length of seventy inches. The average length of the hair of man's head, though short, is indeterminable for obvious reasons, hence shortness cannot exclude human hair, though length may exclude animal hair.

The range of natural color of hair is very limited, but the peculiarity of its arrangement in individual shafts is, in several instances, distinctive. A parti-colored shaft is not found in human hair, but does appear on the red squirrel, *Sciurus hudsonius*, where there are alternate sections of tawn and black from root to tip; on the gray squirrel, *Sciurus Carolinensis*, black and white; on the common rat, *Mus rattus*, black and white; on the rabbit, *Lepus sylvaticus*, yellow, black and white; on the domestic cat, commonly called tortoise shell, *Felis domestica*, black, yellow and white, gray and white; on the guinea pig, *Cavia cobaya*, yellow or tawn and white and on the body of the Scotch terrier, *Canis familiaris*, tawn and black. Deeply pigmented shafts, whether from man or other creature, are lacking in color at the root end. Black and dark brown hair characterise many races; that of the Indian, Negro and Celestial is jet black. Blonde and golden hair is less prevalent and red appears in individuals and families scattered among the lighter haired peoples. Upon the same body and upon the same head hairs very different in color are frequently found. So-called golden and auburn hairs are made up of blonde and red hairs, mingled in varying proportions. The beard and body hairs of man are generally lighter than those of the head. The color of hair dyed with lead, bismuth or silver salts may be readily removed by means of 20 per cent. nitric acid. Such color may be detected by subjecting to microscopic examination, where it is seen to be superficial, with particles of pigment adhering to the surface of the shaft and occasional spots present unstained. "Under the microscope dyed hair exhibits a far greater degree of regularity of color than is found in nature."

The form of the hair shafts of human and other hairs is very generally round. Exceptions to this are the hair of the coney, *Hyrax syriacus*, the shafts of which are flat and that of the Negro, which is oval, determined on cross section. The downy under hair of furs, while often woolly and sinuous in outline, are round.

The form of terminations of the shaft indicate in a measure its source. Long tapering points are not present in human body hair. The hair of nearly all common furs of unshorn domestic animals have sharp points. The fine hair from the seal, *Callorhinus ursinus*; coney, *Hyrax syriacus*; beaver, *Castor Canadensis*; and otter, *Lutra Canadensis*, are frequently blunt from having been sheared. The hairs from the heads of men are blunt, either sharply cut off or slightly worn; those from the eyebrows, eyelashes and some body hairs are fine-pointed, those from the eyelid and brow terminating as a cone. The hairs from the head of a woman may or may not be pointed sharply. Often it is torn, frayed and broken from frequent brushing and combing. Hairs that have been removed violently from the head may be crushed, frayed, with a portion of the epithelial covering removed, or be in continuity with the root and bulbous portion. When so torn out they may be accompanied by blood in small quantities and epidermic scales.

It is a quality of all over hairs that their greatest diameter is in that part of the shaft projecting beyond the under hair. From this enlargement the shafts taper to a point, the tip of the shaft, and toward the base or root end, where it frequently is less than one-fifth of the diameter of midshaft. Under hair has alternate constrictions and enlargements in the diameter of the shaft, from root to tip. Hair from the head of a woman is similarly characterised and there may be as many as fourteen demonstrable changes in diameter in a single shaft. The shaft does not progressively diminish in diameter from root to tip, but may be apparently uniform throughout the major part of its course. In addition to variations in individual shafts, hairs from the same body, from the same head may differ much in the diameter of their shafts. The locally growing body hairs are coarser than the hair from the head. The hair from the mane of a horse, *Equus caballus*, may be finer than that from the head of a Chinaman and six inches from the ends of long mane hairs may be as fine as hair from a woman's head. There is nothing in the diameter of the hair from the South American monkey to distinguish it from black human hair. This, together with its jet black color and length, makes it difficult to isolate from human hair. The coarsest human hairs are dark in color, the finest are the blonde and golden hairs.

The hair cuticle is composed of a single layer of imbricated scales, which envelope the entire surface of the shaft. Owing to their peculiar shingled arrangement they are frequently imperceptible, except at the margin, where they appear as delicate serrations, such serrations distinguishing the shafts of cat's hair, *Felis domestica ;* seal, *Callorhinus ursinus ;* and coney, *Hyrax syriacus.* The under hairs of all furs are distinctly marked in this manner. In the raccoon, *Procyon lotor;* coney, *Hyrax syriacus;* Russian sable, *Mustela zibellina;* marten, *Mustela Americana;* mink, *Putorius vison;* rat, *Mus rattus;* otter, *Lutra Canadensis;* beaver, *Castor Canadensis;* chinchilla, *Chinchilla lanigera ;* and cat, *Felis domestica*, the scales apparently flare out from the shaft at their distal ends and vary in length with the diameter of the shaft ; where it is broad they are shorter and more closely set, where narrow, they are longer and may be several times longer than the diameter of the shaft. In wool from sheep, *Ovis aries*, with its varieties, Astrakhan and Shiraz, and in long silky hair from the Angora goat, *Capra hircus*, variety. *Angorensis*, the scales are visible, not only as serrations, but also upon the surface of the shaft. Upon human white hair and the white hair of the horse very delicate transverse striations may be seen which correspond to the imbrications of the scales. These may be more readily demonstrated by staining lightly with Gabbet's methylene blue. The hair shaft from the Chinese goat, *Capra hircus*, is marked by a spiral arrangement of its epithelial covering. The serrations of the coarse overhairs are more distinct at the base than in any other portion of the shaft, and generally where the shaft is widest there the scales are less distinct. A rootless and pointless hair indicates by the arrangement of its scales the source of growth, for the free end of the imbrication points toward the free end of the shaft. In many hair shafts there appears to be a definite relation between the scales of the cuticle and the pith cells of the medulla. This is best seen in the hair shaft (fine) of the red fox, *Vulpes fulvus.* The epithelial scales on the hair shafts of the horse, *Equus caballus ;* cow, *Bos domestica ;* dog, *Canis familiaris ;* pig, *Sus scrofa*, and man are fine, closely set to the shaft and have free distal ends that appear sharp at the margins. Ordinarily, the cuticle is not pigmented, but in the black human hairs and hairs from the cow, *Bos domestica ;* horse, *Equus caballus ;* South American monkey, *Colobus vellerosus ;* and dog, *Canis familiaris*, it may be intensely black. The cuticle may be removed from the shaft by treating with strong caustic potash or sulphuric acid. When so removed it may appear as a homogeneous membrane.

The cortical substance of the shaft is singularly scant in the hair of the rat, *Mus rattus ;* red, gray and black squirrel, *Sciurus hudsonius*, *Carolinensis*, and *niger ;* rabbit, *Lepus cuniculus* and *Lepus sylvaticus*, and cat, *Felis domestica*, more abundant in that of the dog, *Canis familiaris ;* horse, *Equus caballus ;* cow, *Bos ;* raccoon, *Procyon lotor ;* pig, *Sus scrofa ;* otter, *Lutra Canadensis ;* beaver, *Castor Canadensis ;* skunk, *Mephitis mephiticus ;* musk rat, *Fiber zibethicus ;* guinea pig, *Cavia cobaya ;* mink, *Mustela vison ;* opossum, *Didelphys Virginiana ;* and coney, *Hyrax syriacus*, and makes up the greater portion of the shaft of the seal, *Callorhinus ursinus ;* South American monkey, *Colobus vellerosus ;* lamb, *Ovis aries ;* goat, *Capra hircus* variety *Angorensis*, and of many of the under hairs of the otter, badger, skunk and coney. The pigment of colored hairs lies within the cortical substance. It is generally present in minute granules that have a linear arrangement parallel to the axis of the shaft and apparently deposited between the elements of the cortical substance, and as diffuse pigment. Both forms are equally distributed between the cuticle and medulla in some hairs, especially human, dog, horse and many others, but in the squirrel, cat, rat, mouse, rabbit, hairs having wide and complex central piths, it appears to be deposited among the cells of the medulla, the cortical substance being clear. In many of the darker shades of hair, the pigment is so dense as to obscure the structure of the shaft. This may be removed by treating with hydrogen peroxide or strong nitric acid, the shafts being immersed in the former for a number of hours, in the latter, but a few minutes or seconds. Hair that is turning gray may have isolated granules of pigment present in the cortical substance. In blonde hair the granular pigment is lacking, as it is also from perfectly white hair. Granular pigment is best seen in red hair (human) and diffuse pigment in blonde.

In the darkest shafts there is a diminution of color toward the root end. The structure of the cortical substance may be demonstrated by macerating in concentrated sulphuric acid. White hair taken from the bodies of animals are milky white, excepting the under hair from the wolf, *Canis occidentalis;* the white horse, *Equus caballus*, which is pearly white, as is also human hair.

The cellular structure of the medulla is, in many instances, the most striking characteristic of the shaft. In the fine hair of the seal, *Callorhinus ursinus;* otter, *Lutra Canadensis;* lamb, *Ovis aries;* goat, *Capra hircus*, and the hairs of children it is absent or at least undemonstrable. In perfect hairs it does not extend the entire length of the shaft, being absent from the root end and tip, and in many appearing as a narrow line that frequently is broken. The diameter of the pith in its relation to the diameter of the entire shaft is constant, the dimensions of the medulla elements changing with the dimensions of the shaft, for where the shaft is broad the elements are broad and shorter, where the shaft is narrow they are narrow and longer. This is clearly demonstrated in all under hairs. In the hair of the rat, *Mus rattus;* mouse, *Mus musculus;* red, gray and black squirrel, *Sciurus hudsonius*, *Sciurus Carolinensis* and *Sciurus niger*, red, gray and white Arctic fox, *Vulpes fulvus*, *Vulpes Virginianus*, *Vulpes lagopus*, wild and pet rabbit, *Lepus sylvaticus* and *Lepus cuniculus*, and domestic cat, *Felis domestica*, the cells are disposed to appear much like the kernels of corn upon the cob. When the shafts are very coarse, as in the cat, this arrangement is not preserved as in the under hair, but there appears to have been a destruction of the central cells. Where the under hair has a medulla, it presents as a string of spherical or cylindrical beads. In other portions of the same shaft it may appear as a series of minute discs in close apposition. These variations are found in all but human hairs. In the over hair of the dog, horse, cow and many others, the cells are larger, extending across the entire width of the medulla, which occupies a third or more of the diameter of the shaft. In human hair the cells of the medulla are cuboidal or irregularly spherical, they are not generally continuous through the shaft, but clusters of such cells, which look not unlike a tangential section of the ray cells present in pine wood. Where the central cells have been destroyed and the medulla has been converted into a central canal or air space, in light hairs it appears as an irregular black line that rarely occupies more than one-fifth to one-third of the diameter of the shaft. In darker hair it is present often as a narrow line of light.

Fibers that may appear as hair to the naked eye are cotton, linen, silk and wool (here considered as a fiber because worn for domestic uses). Cotton fibers, under the microscope, appear as flattened bands that are twisted and sharply bent ; linen fibers are rectilinear, have nodes or jointed markings at irregular distances and taper rapidly to a point ; silk is cylindrical, free from all markings and refracts light powerfully ; wool has peculiar, readily distinguishable surface markings corresponding to the imbrications of the shaft.

In distinction from human hair, then, that of the rat, *Mus rattus* ; mouse, *Mus musculus*; squirrel, *Sciurus hudsonius*, *Carolinensis* and *niger;* fox, *Vulpes fulvus*, *Vulpes Virginianus* and *Vulpes lagopus*, and cat, *Felis domestica*, has a parti-colored shaft and a wide medulla with a fenestrated structure and exceedingly narrow cortical substance ; that from the horse, *Equus caballus;* cow, *Bos;* dog, *Canis familiaris;* raccoon, *Procyon lotor;* skunk, *Mephitis mephiticus;* beaver, *Castor Canadensis;* otter, *Lutra Canadensis;* guinea pig, *Cavia cobaya;* mink, *Mustela vison;* musk rat, *Fiber zibethicus;* pig, *Sus scrofa;* chinchilla, *Chinchilla lanigera;*

opossum, *Didelphys Virginiana;* marten, *Mustela Americana;* Russian sable, *Mustela zibellina*, differs by the character of the medulla, its large cells and width compared to that of the shaft ; that from the lamb, with its varieties, Astrakhan and Shiraz, and the goat, Chinese and Angora, by the absence of a medulla and its characteristically clear and distinct cortical cells ; that of the seal by the distinct laminate shape of its scales and lack of a medulla, and from the hair of the coney, *Hyrax syriacus*, by its flattened shaft. Some human hairs differ imperceptibly from that of the South American monkey, *Colobus vellerosus.* If a section of hair or hairs be presented, the differences noted above between human and other hairs may suffice to distinguish it, but exceptionally white hair from the mane of a horse cannot be differentiated from that of the human head, presenting the same homogeneous cortical substance, narrow medullary canal and delicate transverse surface markings. The hairs of the cocker spaniel and skye terrier have been affirmed to be like human hair. My experience does not corroborate that observation, the medulla being much wider, more regular and made up of larger cells than are present in human hair. In conclusion, then, it may be stated in answer to the questions already given : a hair whose origin is unknown ought not to be positively declared human, though the probabilities be very strong in evidence of that fact. Hairs may appear similar in structure to some human hair, but though a hair be similar to or like a human hair, that fact does not necessarily justify the belief that it is human hair.

PLATE I.

Fig. 1. Hair from a coney, *Hyrax syriacus.*
Fig. 2. Hair from a cat, *Felis domestica.*
Fig. 3. Hair from a white horse, *Equus caballus.*
Fig. 4. Hair from a gray rat, *Mus rattus.*
Fig. 5. Hair from a Chinese goat, *Capra hircus.*
Fig. 6. Hair from a seal, *Callorhinus ursinus.*
Fig. 7. Hair from an opossum, *Didelphys Virginiana.*
Fig. 8. Hair from a pig, *Sus scrofa.*
Fig. 9. Hair from an otter, *Lutra Canadensis.*
Fig. 10. Hair from a skunk, *Mephitis mephiticus.*
Fig. 11. Hair from a musk rat, *Fiber zibethicus.*
Fig. 12. Hair from a mink, *Mustela vison.*
Fig. 13. Hair from a raccoon, *Procyon lotor.*

PLATE I.

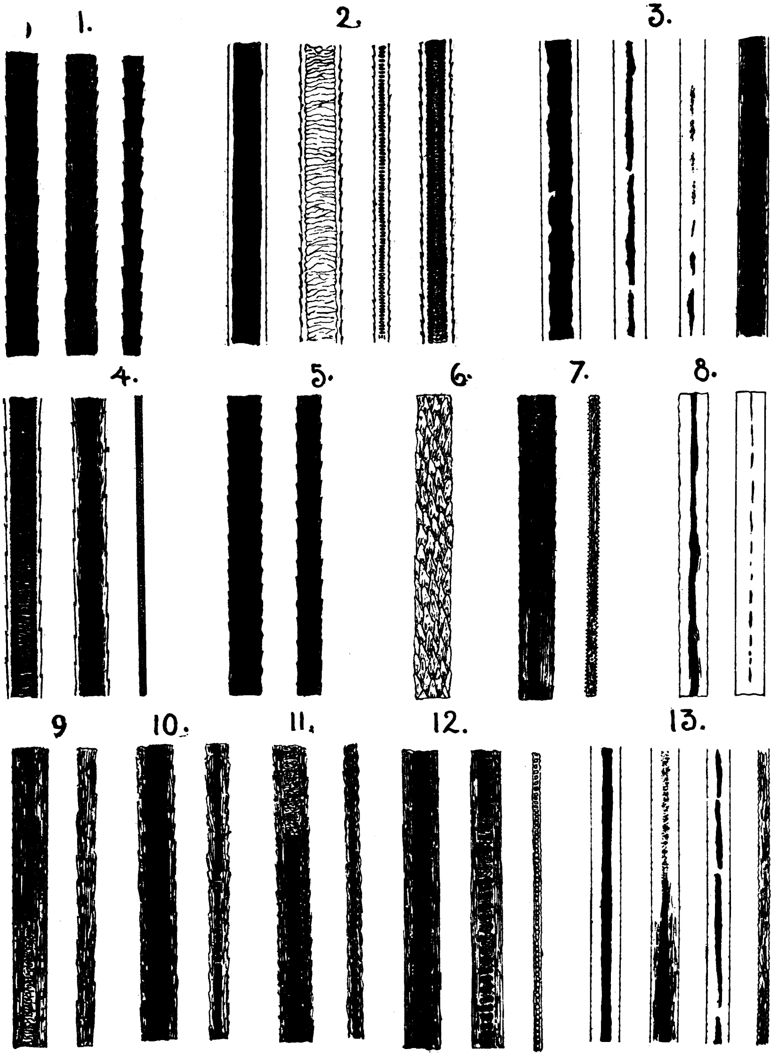

PLATE II.

Fig. 1. Hair from a cow, *Bos domestica.*
Fig. 2. Hair from a rabbit, *Lepus sylvaticus.*
Fig. 3. Hair from a dog, cocker spaniel, *canis familiaris.*
Fig. 4. Hair from a South American monkey, *Colobus vellerosus.*
Fig. 5. Hair from a man, *Homo sapiens.*
Fig. 6. Hair from a man, *Homo sapiens.*
Fig. 7. Hair from a man, *Homo sapiens.*
Fig. 8. Cotton fibers.
Fig. 9. Silk fibers.
Fig. 10. Linen fibers.
Fig. 11. Lamb's wool, *Ovis aries.*

PLATE II.